Affinities of *Lantana camara* in the Australia-Pacific Region

Leon J. Scott[1], Martin A. Hannan-Jones[1,2] and Glenn C. Graham[1]
[1] Centre for Identification and Diagnostics, School of Life Sciences, The University of Queensland, Queensland 4072, Australia
[2] Alan Fletcher Research Station, Queensland Department of Natural Resources and Mines, 27 Magazine Street, Sherwood, Queensland 4075, Australia

Summary Analysis of Random Amplified Polymorphic DNA (RAPD) markers has identified affinities between *Lantana camara* in Australia and the South Pacific, and with *Lantana* spp. from the Americas, including Hawaii. One hundred polymorphic RAPD markers were analysed in *L. camara* from eastern Australia, several sites in Vanuatu and Fiji, and from the Solomon Islands. These were compared to *L. camara* from Hawaii and *L. fucata*, *L. glutinosa*, *L. tileafolia*, *L. undulata* from Brazil and *L. urticifolia* from Mexico.

Within the Australia-Pacific region there is strong affinity between *L. camara* in Australia, Fiji and Vanuatu. When compared with the species from the New World, *L. camara* from all three countries demonstrates an affinity only to *L. urticifolia*. This suggests that *L. urticifolia* is the likely progenitor of lantana in Australia, Vanuatu and Fiji, which is consistent with recent morphological analysis. By contrast, the material analysed from the Solomon Islands showed little affinity to *L. camara* in Australia, Vanuatu or Fiji or any of the *Lantana* spp. from the New World. However, there was a close affinity between *L. camara* from the Solomon Islands and Maui (Hawaii). The knowledge of the affinities between the infestations of *L. camara* in the Australia-Pacific region has already been integrated into the ongoing biological control program.

Keywords *Lantana camara*, *L. urticifolia*, *L. tileafolia*, *L. glutinosa*, *L. undulata*, *L. fucata*, Verbenaceae, biological control, RAPD, taxonomic affinities.

INTRODUCTION

Lantana, *Lantana camara* L. (Verbenaceae), is one of the worst weeds in the South Pacific islands and Australia (Holm *et al.* 1991). Lantana is an aggressive invader of forest communities that blocks natural succession (Lamb 1991) by out-competing native colonisers (Gentle and Duggin 1998), resulting in loss of biodiversity (Fensham *et al.* 1994). Lantana alters the fire regimes in natural systems (Fensham *et al.* 1994). In rangelands, lantana out-competes pasture species, blocks the movement of stock to waterholes and interferes with mustering (Swarbrick *et al.* 1995). Lantana is also toxic to stock (Everist 1981). In the South Pacific, lantana reduces yield and impedes harvesting within coconut and copra plantations (Harley 1993).

As many infestations are not economically controlled with herbicides or impractical to remove manually, biological control is considered the only viable option (Waterhouse and Norris 1987). However, the selection and establishment of successful biocontrol agents has been impeded by uncertainty concerning the relationship between the many forms of the weedy *L. camara* complex throughout the world and the new world *Lantana* species which are potential sources of biological control agents (M. Day pers. comm.).

Lantana camara sensu stricto is a native of the West Indies (Sanders 2001) from where it was collected and introduced into Europe in the early 17th century. *L. camara sensu lato*, naturalised or weedy lantana, was the focus of extensive plant breeding efforts to produce a multitude of different plant forms, flower colours, and varying chromosome complements. In three centuries, some 650 named cultivars or varieties were produced (Howard 1969), in some instances by hybridisation with other, as yet unidentified, species of *Lantana*. These horticultural cultivars were introduced into tropical and sub-tropical countries, such as Australia, South Africa, India and Hawaii where they have naturalised and become weedy. The lantana cultivars were also reintroduced to tropical America where they hybridised with native diploid species such as *L. depressa* Small, in Florida (Sanders 1987).

The majority of lantana naturalised in Australia, including the major weedy taxa, 'common pink lantana' and 'common pink-edged red lantana' are not conspecific with any native taxa in central or South America (Smith and Smith 1982). The lantana in Fiji, Vanuatu and the Solomon Islands has been considered to be similar to some Australian and Hawaiian material (Harley 1993). Previous genetic studies (Scott *et al.* 1997) comparing the main weedy types in Australia ('common pink' and 'common pink-edged red') demonstrated that flower colour was of limited importance in differentiating these types.

This project investigates the genetic affinity of lantana within the Australia-Pacific region with five new world species: *L. undulata* Schrank, *L. fucata* Lindl., *L. tileafolia* Cham. and *L. glutinosa* Poepp. from Brazil; and *L. urticifolia* Mill. from Mexico using RAPDs. The latter three species have been extensively surveyed for biological control agents (Winder and Harley 1982, Winder and Harley 1983, Palmer and Pullen 1995) and are the source of many of the more successful lantana biological control agents in Australia and Hawaii (Julian and Griffiths 1998). This study aimed to establish affinities among introduced varieties in Australia and the South Pacific, and to identify similarities between introduced populations and native taxa from which control agents originate.

MATERIALS AND METHODS

Extensive collections of *Lantana camara* were made along the eastern seaboard of Australia from 16.9°S to 35.4°S. Collections were also made from several sites in Vanuatu, the Solomon Islands and Fiji. Fresh young leaf material was collected and pressed immediately with blotting paper impregnated with thiram (2% w/v), drying was completed as soon as possible in a dry air-conditioned environment. Colour transparencies of flowers were taken for all Pacific collections. The samples that were analysed as part of this study are summarised in Table 1. Sample numbers were restricted in the Pacific, by field availability and the ability to maintain specimens in good condition. Voucher specimens were submitted to the Queensland Herbarium for analysed samples. As previous studies (Scott *et al.* 1997) had demonstrated no significant genetic differences between colour morphs of *L. camara* in Australia, the collections were primarily of 'common pink lantana'.

DNA extraction and RAPD PCR was completed as in Scott *et al.* (1997). Phenetic analysis of the data was completed using NTSYS-pc (Exeter Software, Setauket, New York). These results were compared to Principal Component Analysis (PCA) utilising Genalex (Peakall and Smouse 2001).

RESULTS

The two distinct analytical approaches, phenetic and PCA, produced congruent interpretations of the data. When compared to the five new world species, *L. camara* from Vanuatu and Fiji have greatest affinity with *L. urticifolia*, indicating this is the most likely progenitor. Two individuals from a village garden on Tanna Island, Vanuatu, which are more similar to *L. tileafolia* are the exception.

The Solomon Islands population showed limited affinities to any of the New World species tested, but has a distinct affinity with the population from Maui. Of particular note was the spectacular success of biocontrol that had been achieved within the Russel Island Plantation Estates (RIPEL) on Mbanika Island. In 1993 the 'Hawaiian pink' variety was common throughout the plantation (Harley 1993), subsequently *Uroplata girardi* has successfully controlled lantana in the plantation.

Table 1. Summary of samples processed.

Country	Source	Number of populations	Total number
Australia	East Coast, 16.9–35.4°S	Continuum	30
Vanuatu	Efate Is.	1	5
	Tanna Is.	1	5
	Malekula Is.	1	5
	Santo Is.	1	5
	Miscellaneous	–	5
Solomon Islands	Mbanika Is.	1	10
Fiji	Viti Levu	3	12
	Vanu Levu	3	12
	Miscellaneous	–	1
Hawaii	Maui	1	5
	Kokee	2	10
	Kapaa	1	5
Brazil	*L. undulata*	1	3
	L. fucata	1	7
	L. tileafolia	2	14
	L. glutinosa	1	7
Mexico	*L. urticifolia*	1	4

When compared to the New World species, the Australian populations have closest affinity with *L. urticifolia* from Mexico. Comparisons between populations of *L. camara* from Australia and the Pacific showed affinities between Australia, Vanuatu and Fiji. This is of little surprise given all three have affinity with *L. urticifolia*.

DISCUSSION

RAPD analysis of *Lantana camara* from Australia, Vanuatu, the Solomon Islands, Fiji and Hawaii, along with *L. fucata*, *L. glutinosa*, *L. tileafolia* and *L. undulata* from Brazil and *L. urticifolia* from Mexico, has characterised affinities among these populations with significant implications for future biological control.

Affinity between *L. camara* assessed from Australia, Vanuatu and Fiji with *L. urticifolia* from Mexico is consistent with recent taxonomic review (Munir 1996), which indicated that *L. camara* from Australia has close affinity with *L. moritizana* Otto & Dietr. It has further being proposed that *Lantana* sect. *camara* consists of only three species complexes; based on *L. camara*, *L. hirsuta* Mart. & Gal. and *L. urticifolia* (R. Sanders pers. comm.) with *L. moritizana* placed within the *L. urticifolia* complex. The placement of lantana from Australia within the *L. urticifolia* species complex is consistent with the affinity identified here. Other Australian material (not included in this analysis) has been identified as *L. camara* × *L. urticifolia* (M. Day pers. comm.), also entirely consistent with the genetic analysis.

Surveys of *L. camara* in Vanuatu and Fiji identified 'common pink' and 'common pink-edged red' (Fiji only) types as the most common (Harley, 1993), as is the case in Australia. The affinity between lantana from these nations and *L. urticifolia* identified by this genetic analysis, recent taxonomic review and field surveys indicates that if successful control agents are established in Australia, transfer to Vanuatu and Fiji should not be constrained by the plant genetic makeup. As a progenitor of these populations, *L. urticifolia*, should be targeted for future surveys for biocontrol agents.

The population from Mbanika Island in the Solomon Islands has no close affinity to any of the five New World species, but is closely allied to *L. camara* from Maui. The Solomon Islands population may have originated in Hawaii, directly or indirectly, or the two infestations may share a common source. The infestation in the copra plantation on Mbanika Island was reported to be relatively recent by RIPEL staff (post World War Two). This island hosted one of the largest U.S. military bases in the Pacific, outside of Hawaii. A potential source of the infestation is the wholesale movement of equipment and personnel from Hawaii to this island during the Second World War.

Effective biological control has been obtained with *Uroplata girardi* on Mbanika Island. Interestingly, the other highly successful release of *U. girardi* was in Hawaii last century (Waterhouse and Norris 1987). By contrast to the successful introduction to the Solomon Islands of agents that have proved successful in Hawaii, many introductions of several such species into Australia have failed to achieve effective widespread control (Julian and Griffiths 1998, Day pers. comm.).

Genetic analyses are valuable predictive tools when trying to identify new control agents or transfer previously successful agents. Genetic analysis can identify progenitors, even for species as genetically complex as *L. camara*, allowing surveys for potential control agents to be targeted to these species. In transferring existing agents that have proved successful, genetic analysis can identify if the target population is genetically similar to the currently controlled population. The importance of this is demonstrated by the success of *U. girardi* in the genetically similar populations of lantana in Hawaii and the Solomon Islands. By contrast, control has been ineffective on the relatively distantly related populations in Australia.

The results of this survey have already been incorporated within the control programs at the Queensland Department of Natural Resources and Mines. Further genetic surveys of *L. urticifolia* across its native range should allow greater resolution in identifying populations most similar to lantana in Australia, Vanuatu and Fiji, and these should be surveyed for potential control agents.

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